Propagation modelling towards the design of drone-borne GPR for humanitarian applications

In this paper, we shall address the electromagnetic wave propagation issues that will critically determine the radar-link budget for assessing the feasibility of a drone-borne ground penetrating radar sensor for humanitarian applications, particularly in the context of disaster management.

The main challenges addressed in this contribution are the estimation of propagation-loss and wave-dispersion in the sub-surface medium. These features are the key constraints on the performance of a GPR system. In this regard, a realistic range of values of the electrical properties of soil and water volumes will be drawn from open literature. In the area of hardware realization, the key problem will be to have a final radar-unit weighing no more than a few kilograms that can be mounted, powered, and flown on a small copter-type-based carrier (drone) capable of autonomous operation.

The main application of the sought ground-penetrating drone-mounted radar would be to detect not only the sub-surface environment but also to possibly detect human beings buried under debris generated by landslides or the collapse of buildings.

We shall report on the frequency and polarization dependent scattering from planar soil surfaces, attenuation due to propagation within lossy soil, and dispersion of radar signals penetrating into the sub-surface region. Using these results, the objective will be to present a detail overview of estimates of received echo power using radar parameters to be proposed.

In particular, we shall propose the most feasible design of a compact drone-borne GPR suitable for humanitarian applications. Additionally, in doing so, the proposed GPR radar will also be examined against the frequency dispersion properties in order to report on possible modulation depths for FMCW mode of operation.

In the analysis to be reported, a radar equation for a drone-borne GPR will be formulated that permits the inclusion of the aforementioned propagation effects.

The analysis to be presented will identify the limits of the useful application of such a system that could be constructed with the technologies available today.